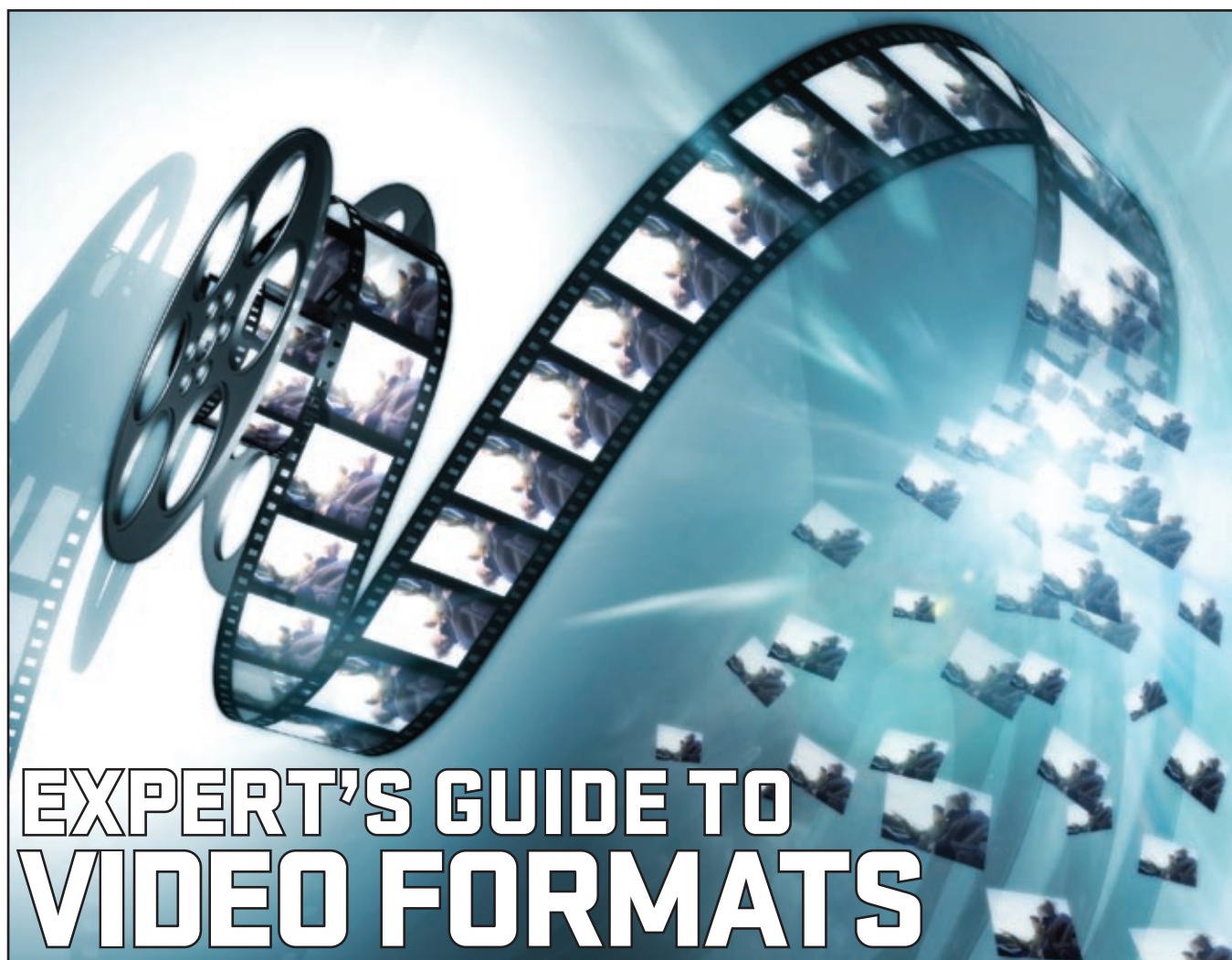




Phones, MP3 players and games consoles all offer the promise of video playback, but getting it to work can be a drama. Ben Pitt takes the mystery out of video files

One of the best things about digital information is that it is easy to move around and can be used in many different ways. That's the theory, but the reality isn't always so straightforward. This is never truer than when dealing with digital video. With so many formats and playback devices in common use, the possibilities for watching video are seemingly endless, but so too is the potential for confusion.

Digital video is a minefield because it has so many facets. Your new mobile phone may have MPEG4 Video emblazoned across its packaging but the file you load on to it might not play if it is not the right variation of MPEG4, encoded at the correct resolution, frame rate and bit rate. It will also need to use the correct audio format, sample rate and bit rate. And it needs to be wrapped in the correct container file type. If that sounds hopelessly complicated, don't despair. With a few key concepts under your belt, you'll be able to watch video on your own terms rather than be at the mercy of the technology.

Over the next four pages we explain the ins and outs of video formats and how to go about converting files. Armed with this knowledge, you should be able to find the right software and settings to enjoy video on any combination of devices, now and in the future.

WHAT'S IN A VIDEO FILE?

We're tempted to compare the various parts of a video file to an onion; in fact, it's more like a walnut. The shell is the file type, otherwise known as the container. The type of container used is denoted by its file extension. Windows doesn't display file extensions by default, but when dealing with video it's handy to be able to see them. Open My Computer and click Tools, Folder Options, select the View tab, untick Hide extensions for known file types and click OK.

Common container types are AVI, MPG, WMV and MOV, although there are plenty of others. These names don't necessarily tell you much about the data within the file and some containers can hold only certain types of video data. For example, a WMV container supports only WMV video and WMA audio. Other containers, such as AVI, can hold a theoretically limitless variety of video and audio formats.

The main practical purpose of a container, from the user's point of view, is to provide compatibility with a specific hardware playback device, and to specify which software fires up when you double-click the file on your PC. Typically WMV files will open in Windows Media Player and MOV files will load in QuickTime, but most playback software can open a wide variety of container types. To change the default player for a particular

container, right-click the file and select Open With, Choose Program... You'll be given a list of compatible software, so select the one you want, tick the box marked Always use the selected program to open this kind of file, and click OK.

Inside the walnut shell, things get more interesting. Like a walnut kernel, a video file has two halves – the video and the audio. They're clearly linked, but they can be thought of as entirely separate components. The only thing they always have in common is their duration.

VIDEO CONTENT

The video component is made up of lots of discrete images, or frames, played in quick succession. These have two key variables: the resolution of each frame and the number of frames per second. UK TV broadcasts and DVDs use 25 frames per second (fps), and each frame comprises 720x576 pixels. This is known as the PAL standard. However, as if to prove that nothing is ever simple with digital video, neither specification is quite what it seems.

The aspect ratio is the proportion of the video's width to its height. Common ratios are 4:3, the shape displayed by old-fashioned TVs, and 16:9 (also known as widescreen). Logic would suggest that you could tell the aspect ratio of a video by its resolution, but 720x576 is actually equivalent to 5:4. The reason PAL has a



4:3 aspect ratio is because its pixels are not square. Each of the 720x576 pixels is slightly stretched during playback to give the correct aspect ratio. Widescreen PAL footage uses exactly the same 720x576 resolution, but stretches it further to give a 16:9 aspect ratio.

Fortunately, the average viewer rarely has to worry about aspect ratios and non-square pixels, as the conversion software and playback device usually takes care of it automatically. However, if you have trouble with squashed playback or black bars at the top or sides of converted videos, the aspect ratio and non-square pixels are the areas to investigate.

Frame rates have their share of complications, too. 75 years ago TV engineers found that frame rates in the region of 25fps didn't look very smooth and caused a distracting flicker on TV screens, but significantly higher frame rates demanded too much bandwidth for transmission. The solution was to double the frame rate, but for each frame to carry only half the picture, which was split into odd and even horizontal lines; each half is known as a field. This technique, known as interlacing, was surprisingly effective at giving the impression of the full resolution at high frame rates, and is still used today for TV broadcasts around the world.

Interlaced footage looks great on displays that are designed for it, such as CRT TVs. However, modern displays such as LCD screens, plasmas and projectors aren't interlaced. They use what is known as progressive scan, which shows frames in their entirety, one after the other. This is why interlaced footage such as TV broadcasts and video camera footage can look awful on an LCD screen.

The problem manifests itself in 'jaggies', a sawtooth-like pattern along the vertical edges of objects as they move across the screen. This is the result of each frame being made up of two fields, captured at different times – one with all the odd horizontal lines of pixels and the other with all the even lines. Turning interlaced footage into smooth progressive scan requires clever processing, and some conversion software and playback devices perform this badly or not at all. Fortunately, film is progressive scan, so interlacing issues don't affect movies when viewed on modern displays.

AUDIO CONTENT

The other half of our walnut kernel is the audio, which has its own set of specifications. These include the number of audio channels, the sample rate and the bit depth. Using a single channel, known as mono, is common in old films and basic video capture modes on digital cameras. Two channels (stereo) is standard for TV broadcasts, while most DVDs include a choice of stereo and 5.1 surround soundtracks. Surround sound is worth having if your playback equipment supports it but, for most situations, stereo is the right choice.

The sample rate dictates how much high-frequency content your recording can contain. The standard sample rate used on DVD Video discs is 48kHz, which can reproduce frequencies up to 24kHz. This is higher than the 20kHz limit of human hearing. The bit depth dictates the difference between the loudest and quietest possible sound, and is typically 16- or 24-bit. A bit depth of 16 is plenty, and using 24-bit is pointless when you start introducing compression into the equation.



▲ TV broadcast and video camera footage is interlaced, which means that each frame is made up of two fields captured at different times. One provides the odd horizontal lines, the other the even lines. This can produce 'jaggies', which are sawtooth-like edges to objects, when viewed on LCD screens that don't support interlaced footage

COMPRESSION CHAMBERS

Raw digital video data occupies a huge amount of storage space. The PAL specifications need about 250 megabits per second (Mbit/s), which equates to 110GB per hour. This is why compression is used whenever video is stored or transmitted across networks. Compression algorithms are known as codecs, which is short for compressor-decompressor. Codecs vary greatly in how efficiently they compress video.

The least efficient types, such as the DV codec used by MiniDV cameras, simply store a succession of JPEG-style images, and reduce PAL's 250Mbit/s video down to 25Mbit/s. MPEG2, used by DVD Video discs and Freeview TV, is better. Instead of describing each frame from scratch, it describes how each frame differs from the previous one. This reduces PAL video to around 4-6Mbit/s. The most advanced codecs, such as H.264, use various refinements of MPEG2's techniques to achieve file sizes of around 2Mbit/s while maintaining high quality.

Smaller file sizes are clearly better, but there are disadvantages to using efficient codecs. They are harder to encode and decode, so encoding takes longer and decoding requires a faster processor for glitch-free playback.

Audio codecs vary less in quality. MP3 is by far the most popular and most people find 128Kbit/s files hard to distinguish from CD quality. Other formats, such as WMA and AAC, are a little more efficient and sound better than MP3 when encoded at 96Kbit/s or lower.

BALANCING SETTINGS

There are two reasons to convert a video file from one format to another. One is for compatibility, so that a specific playback device can play it. The other is to reduce the file size. High-quality video often runs into many gigabytes, even after using MPEG2 compression, and there simply isn't enough room to put these files on a mobile phone, PlayStation Portable (PSP) or iPod. In these circumstances, a working knowledge of video specifications is very useful.

Let's imagine we have recorded a one-hour TV programme using a digital TV tuner. Freeview TV is broadcast as MPEG2 video at around 4Mbit/s. There are eight bits in a byte, so 4Mbit/s is equivalent to 0.5 megabytes per second (MB/s), or 30MB in a minute and 1.8GB for the hour-long programme.

The 1.8GB file might fit on a portable device and, with luck, it might even play, but it will consume more space than is necessary. We can halve the file size simply by converting to a more efficient codec such as H.264 or WMV. As long as the playback device supports this codec, it will play. That's a good start, but we're probably still wasting storage space.

PAL runs at 720x576 pixels per frame, and while computers and TVs can display it in all its glory, the screens on handheld devices are seldom so detailed. There's no point in having a video file with a higher resolution than the screen it's viewed on, especially as reducing the resolution can save lots of storage space.

A resolution of 320x240 uses less than a fifth of the number of pixels as the original 720x576 resolution, so we can reduce the video bit rate by a similar degree. This means we can convert our 4Mbit/s, PAL-resolution MPEG2 file into 320x240-pixel H.264 video at 350Kbit/s, using around 160MB for an hour. However, we can't forget about the audio, which at 128Kbit/s still consumes around 58MB per hour. To reduce this, we could drop the audio bit rate to 96Kbit/s, or convert from stereo to mono and reduce the bit rate to 64 or 48Kbit/s.

If yet more space-saving is required, we could try lowering the video bit-rate further. This will result in heavier compression artefacts, which will spoil the appearance of the video, but it may be a bearable sacrifice. Another option is to reduce the frame rate, but this isn't recommended in most instances. Going from 25fps to 12.5fps is easy for the conversion software, as it simply discards every other frame, but such a slow frame rate will be distractingly jittery. Converting from 25fps to 15 or 20fps is much harder as the source and destination frame rates don't match up, and the results are often quite unpleasant to watch.

DEMYSTIFYING MPEG4

So far we've covered the general principles of digital video, which should apply whether you intend to convert video to play on your new video-equipped MP3 player, an aging media-streaming device or the mobile phone you'll buy in 2010. Let's now take a look at the formats currently in common use.

MPEG2 is by far the most widespread format, thanks to its use on DVD Video discs



GUIDE TO VIDEO FORMATS

and standard-definition digital TV broadcasts. However, most newer gadgets, such as iPods, PSPs and mobile phones, use MPEG4. More versatile devices, such as PCs, streaming media players and portable media players (PMPs), tend to support both MPEG4 and MPEG2, but the former's smaller file sizes make it preferable, given the choice. High-definition (HD) video, which typically has a resolution of 1,920x1,080 or 1,280x720 pixels, is regularly found in both MPEG2 and MPEG4 formats, but MPEG4 is likely to dominate in future.

MPEG4 is popular and very efficient, but it's also an unwieldy mess of acronyms and quasi-standards. The first thing to realise is that there is more than one type of MPEG4. Resolutions and frame rates vary, but so does the codec itself. In fact, the MPEG4 specifications allow for all sorts of extra content such as 3D and vector graphics, fonts, subtitles and more. As such, to say that a device supports MPEG4 is hopelessly vague and no guarantee that a particular MPEG4 file will play on it.

There are 23 so-called Parts to the MPEG4 specification. Fortunately, we only really need to know about four of them. Part 14 is a container format with an MP4 extension, which is compatible with iPods and PSPs. Part 12 is another container with a 3GP extension, and is commonly used by mobile phones.

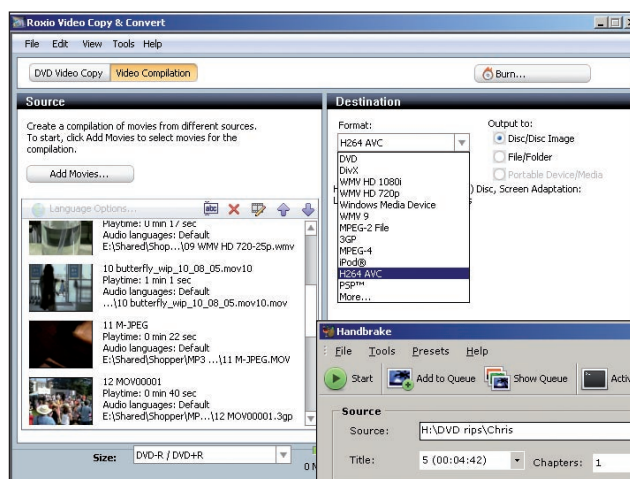
Part 2 is a codec known as Advanced Simple Profile, or ASP. It is used in various well-known video formats such as DivX, Xvid and Nero Digital. Unfortunately, these formats spoil our basic premise of codecs and containers. DivX combines MPEG4 ASP video with MP3 audio, which makes it sound more like a container. Sometimes it is, when it has a .divx file extension. However, DivX files are more often saved in AVI containers, which makes DivX seem more like a codec. Xvid and Nero Digital don't have their own container formats. Nero Digital files use AAC audio and come in an MP4 container, while Xvid typically uses an AVI container. Players that can handle one of these formats won't necessarily be able to handle the others, so it's best to think of DivX, Xvid and Nero Digital as video codecs, even though they're all based on the same underlying codec.

The other MPEG4 codec in widespread use is Part 10, which also goes by the names Advanced Video Codec (AVC) and H.264. It's used by Apple's iPod, Sony's PSP, Blu-ray discs and most HD TV broadcasts, and has a slight quality advantage over MPEG4 ASP. These devices refer to it as H.264 rather than inventing some extra layer of jargon to contend with, although Nero calls it Nero Digital AVC. H.264 is subdivided into 14 Profiles depending on the precise implementation of encoding features, but life to is too short to worry about these. In our experience, they've never been an issue.

CONVERSION THERAPY

You may be slowly losing the will to live by now, but the good news is that we're finally ready to convert some video.

The first thing to do is to work out the requirements of your playback device. What's the most efficient video codec it supports, what audio codec does it support and what container should it be wrapped up in? Next, check the maximum supported resolution and the resolution of the screen. If either is lower than PAL resolution (720x576 pixels), that's your



▼ Roxio Copy & Convert costs £18 and uses non-customisable export templates, but it's extremely easy to use

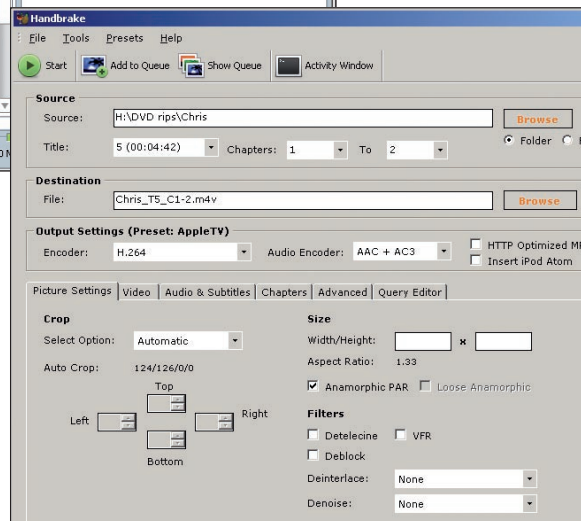
▼ Handbrake only converts MPEG2 files and unencrypted DVDs to MPEG4 formats, but it does so extremely effectively

target resolution. The instruction manual or Google should help you find this information. Finally, consider the storage space available. PAL MPEG2 consumes around 2GB per hour, while MPEG4-based formats at full resolution consume between 500MB and 1GB per hour. If that's too much data, consider dropping the resolution to allow lower bit rates to be used. To convert a selected bit rate into a file size, multiply its value (in Mbit/s) by the video's duration in minutes and then by 7.5, which is a short cut to dividing by eight to convert bits into bytes and then multiplying by 60 to turn seconds into minutes. Don't forget to include both the video and audio bit rate.

Finally, you need some software to carry out the conversion. There's a huge variety available, including freeware, shareware and commercial products. However, few conversion tools have the four qualities required for creating the best results. One such quality is support for a wide range of import formats. You might want to convert a DVD one day, a TV tuner recording the next and a downloaded DivX movie and home video in DV format the next, and you won't want to have to switch software for each project. We should point out here that defeating the CSS encryption used on commercial DVDs to prevent copying is illegal, and none of the software mentioned here can do so.

Comprehensive export options are important, too, although perhaps less so if you only need to convert to a single format for playback on a specific device. The interface should provide extensive control over encoding settings but be straightforward and friendly, with the ability to save and recall preset profiles once you have found the best settings. The fourth thing it needs is high-quality conversion. Compression quality is defined by the codec, but not all software is equal in its ability to adjust resolutions, de-interlace footage and handle aspect ratios reliably.

None of the free software we've tried meets all of these criteria, but a couple are decent options for some people. HandBrake (<http://handbrake.fr>) imports only MPEG2 formats (including non-encrypted DVDs) and exports only to MPEG4-based formats, but it's superbly laid out with useful presets, full manual control and excellent output quality.



If you need more import and export options, try Super © (www.erightssoft.com). It supports a wide range of input and output formats and displays options for the container, video codec and audio codec as three drop-down lists across the top. Its options are extremely wide-ranging, but we've found it to be fairly unwieldy, with an untidy interface, awkward handling of aspect ratios, occasional audio distortion or loss of sync with video and other reliability problems. Still, it's free and is a good option if HandBrake's import and export options are too limited.

If you long for a simple life and are willing to pay for it, go for Roxio Copy and Convert (reviewed in *What's New, Shopper* 235). It costs around £18, has comprehensive import and export options and excellent output quality. It lacks full control over the exported video's specifications, relying instead on a drop-down list of presets that cover iPod, PSP, DivX, 3GP, DVD Video and others. As a result, it's far easier to use than any of the tools mentioned above.

However, if you want something that meets all four criteria, go for AVS Video Converter (\$40 from www.avsmmedia.com). It has excellent input and output format support, high-quality output and a simple interface that combines profiles with the ability to adjust any setting. A free version adds an intrusive watermark to files but lets you try the software out before buying.

THAT'S A WRAP

Digital video is littered with pitfalls, and something as simple as watching a video you've paid for, or made yourself, on the screen of your choice is harder than it should be. However, the days of staring blankly at lists of jargon should now be behind you. Finding a system that works for you may still take time, but now you can approach it methodically, and once you've got it right, future conversions should be plain sailing – in theory, at least.



Device squad Encoding video for a particular device

Still not sure which codec, frame rate and resolution to use? Here are a few suggestions for some of the more popular players.

VIDEO ON YOUR PC

Desktop PCs have high-resolution screens, DVD drives, plenty of storage space and lots of playback software. Windows Media Player and QuickTime cover most formats between them, so conversion is often unnecessary. However, if you want to keep a huge video library on your hard disk, consider encoding your files using H.264 wrapped in an AVI container. You can maintain the original resolution and frame rate at around 2Mbit/s with MP3 audio at 128Kbit/s. This will give DVD-quality video that's compatible with Windows Media Player and will consume 960MB per hour of footage. If it's for a laptop with a smaller hard disk, consider dropping the resolution to 384x288 (or 400x228 for widescreen) and the video bit rate to 500Kbit/s to reduce files to 276MB per hour.

Another option for PCs with broadband access is to use the BBC's iPlayer and Channel 4's 4oD software. These make recently broadcast programmes available to download and watch within a certain time limit. Both use the WMV format encoded at around 1Mbit/s, which gives quality that's roughly on a par with Freeview broadcasts.

VIDEO IN YOUR LIVING ROOM

The TV and sofa are a winning combination for watching videos, so if much of the video you watch arrives through your PC, you'll need a way to view it on your TV. The easiest option is to burn videos to DVD. Both Roxio

and AVS's software (see opposite) can create DVD Video discs that play in any DVD player.

For easier access to content stored on your PC, get a streaming media player. These attach to a home network, stream video, audio and photos directly from a PC and display them on a TV. You'll find a group test of these devices in *Shopper 244*. Some support H.264, but not all do. If yours does, encode using the settings described under Video on your PC. If not, go for the most efficient format that it supports, which will probably be DivX. Similar settings will work fine but you may need to raise the video bit rate a little to maintain high quality. Make sure you use an audio codec and container that your streaming media player recognises, too. For more on media streaming devices, see *Advanced Projects* on page 154.

VIDEO ON YOUR IPOD

The iPod is just one of the many video-capable devices available, but its popularity means it warrants particular attention. The whole of the current range, excluding the screenless Shuffle, supports video, as does the fifth-generation iPod. Videos must use the H.264 codec up to 2.5Mbit/s, 640x480 pixels and 30fps, with AAC audio up to 48kHz and 160Kbit/s, wrapped in M4V, MP4 or MOV containers.

Fortunately, pretty much all conversion software has presets for creating files that adhere to these specifications. However, it's worth bearing in mind that the iPhone and iPod Touch's screens are 480x320 pixels, while the other video-capable iPods' screens are just 320x240. As such, 640x480-pixel video is pointless unless you use the iPod to play video on an external display through a dock with

video outputs. When converting, drop the resolution to match the screen and reduce the video bit rate to around 300-500Kbit/s.

As we went to press, the BBC announced that its iPlayer service will soon be available on the iPhone and iPod Touch. However, it will be available only over a WiFi connection and not the Edge mobile network, which isn't fast enough for high-quality video.

VIDEO ON YOUR PORTABLE PLAYER

There are too many different portable video players, video-capable MP3 players and mobile phones for us to provide details on each one. However, the procedure for converting video for each is the same. First, check the manual or use Google to ascertain which format it supports. You'll need to know the video codec (probably H.264, DivX or WMV), the audio codec (probably AAC, MP3 or WMA) and the container type (probably MP4, AVI or WMV).

If you find only some of the information and need to guess the rest, bear in mind that the H.264 codec usually goes with AAC audio and an MP4 container, DivX with MP3 and an AVI container, and WMV with WMA and a WMV container. Most mobile phones use a 3GP container, which usually holds MPEG4 ASP video with AAC or AMR audio.

Encode at a resolution that's no higher than the screen's. Sensible video bit rates are 300Kbit/s for a 320x240-pixel resolution or 100Kbit/s for 176x144 pixels. However, some devices may not support video at the screen's full resolution. The PSP's screen is 480x272, but video is limited to 320x240 pixels or 368x208 for widescreen. **CS**

